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Habitat use and nutrient reserves dynamics of spring migratory mallards in central Iowa

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by

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GENERAL INTRODUCTION

In the past 50 years, research on waterfowl breeding ecology has expanded vastly, enabling waterfowl managers to undertake intensive programs for the betterment of North America's waterfowl populations. Much of this work assumed that conditions on the breeding grounds were population limiting (Pospahala et al. 1974). But there have been suggestions that a scarcity of mallards (Anas platyrhynchos) (Trauger and Stoudt 1978) and other birds (Fretwell 1972) on the breeding grounds may be due to factors away from the breeding grounds. It has been suggested that mallard recruitment is influenced by habitat conditions on the wintering grounds (Heitmeyer and Fredrickson 1981) and by female lipid reserves acquired prior to arrival on the breeding grounds (Krapu 1981). In response to this broader view of the annual cycle and its effect on North American waterfowl populations, there has been a proliferation of postbreeding and wintering waterfowl studies. But it is currently not known when and where hen mallards are acquiring lipid reserves and what habitats are being used during spring migration.

Mallards lose weight throughout the winter (Folk et al. 1966, Sugden et al. 1974, Owen and Cook 1977, Whyte and Bolen 1984), this weight loss because of a reduction in lipid reserves (Jorde 1981). Yet, upon arrival at the breeding grounds, near maximum weight has been reached (Folk et al.

1966, Krapu and Doty 1979, Krapu 1981). This weight gain, due to increased lipid levels, occurs prior to arrival on the breeding grounds (Krapu 1981) and most likely during spring migration as in lesser snow geese (*Chen caerulescens*) (Ankney 1982) and Canada geese (*Branta canadensis*) (Raveling 1979).

It is important to learn when and where hen mallards acquire lipid reserves during spring migration. This information is critical to determine when and where spring migration habitats need to be preserved and/or managed. It then becomes important to identify the types of habitats used by mallards during this period of lipid acquisition. The lack of spring migratory habitat use information is potentially a serious problem because resource managers can not properly manage for mallards without this information. Failure to meet the habitat needs of spring migrants, in association with continuing losses of emergent wetlands (Bishop 1981, Weller 1981) and seasonally-flooded agricultural ponds (Anonymous 1983) in central North America, must ultimately affect waterfowl populations.

The objectives of this study were to 1) learn if or when spring migratory hen mallards acquire lipid reserves in central Iowa, 2) compare this information with studies conducted on the breeding and wintering grounds, 3) determine what influence age, reproductive condition, and molt have on nutrient reserves dynamics, 4) identify habitats used by spring migratory mallards in central Iowa, and 5) determine what characteristics of those habitats influenced mallard use. It is hoped that this information will allow resource managers to better meet the needs of spring migratory waterfowl.

Explanation of Thesis Format

This thesis adheres to the guidelines specified for the alternate format. It consists of two discrete components written for publication, mindful of the requirements and foci of the journals for which they are intended. The contribution of Theodore G. LaGrange, in each case, has been that of co-originator, field worker, and principal author. James J. Dinsmore's contribution has principally been one of coordinator, advisor, and editor.

SECTION I. NUTRIENT RESERVES DYNAMICS OF SPRING MIGRATORY MALLARDS IN CENTRAL IOWA

ABSTRACT

To properly manage for mallards (Anas platyrhynchos), it is critical to understand when and where hens acquire lipid reserves used on the breeding grounds. I collected 43 paired hen mallards during the 1983 and 1984 spring migrations to determine lipid and protein reserves status. The 1984 collections were grouped into premigratory peak (early), migratory peak (peak), and postmigratory peak (late) periods. Late period mallards had greater body and lipid weights than mallards in the two earlier periods. By the late period, mallards had greater body and lipid weights than birds collected on the wintering grounds, and equalled the body and lipid weights of birds collected on the breeding grounds. Therefore, hen mallards are acquiring lipid reserves during the spring migration, especially late in the migration. I propose that these reserves are used for the next migratory flight, thermoregulation, and to allow a shift to invertebrate foods on the breeding grounds. Protein reserves changed little throughout the migration. Failure to meet the energetic needs of hen mallards could lead to increased mortality and decreased recruitment. Habitats containing high-energy and nutritious seeds are needed. Moist-soil areas and seasonally-flooded agricultural lands contain such foods and need to be provided throughout the spring migratory range of the mallard, especially close to the breeding grounds.

INTRODUCTION

In recent years, in response to the suggestion that factors away from the breeding grounds affect waterfowl production (Trauger and Stoudt 1978, Heitmeyer and Fredrickson 1981), there has been a proliferation of wintering-waterfowl ecology studies. Krapu (1981) suggested that lipid reserves acquired before arrival on the breeding grounds influenced mallard reproduction. But it is not currently known when and where hen mallards acquire these lipids.

Mallards lose weight throughout the winter (Folk et al. 1966, Sugden et al. 1974, Owen and Cook 1977, Whyte and Bolen 1984a), because of a reduction in lipid reserves (Jorde 1981). Yet, upon arrival at the breeding grounds, near maximum weight has been reached (Folk et al. 1966, Krapu and Doty 1979, Krapu 1981). This weight gain, due to increased lipid levels, occurs prior to arrival on the breeding grounds (Krapu 1981) and most likely during spring migration as in lesser snow geese (*Chen caerulescens*) (Ankney 1982) and Canada geese (*Branta canadensis*) (Raveling 1979).

It is important to determine when and where hen mallards acquire lipid reserves during spring migration. This information is critical to determine the importance of the spring migratory period to the Mississippi Flyway's mallard population. This information will also help to determine when and where during spring migration habitats need to be preserved and managed for waterfowl, essential in light of continuing habitat losses (Bishop 1981, Weller 1981, Anonymous 1983).

The objectives of this paper are to 1) show when spring migratory hen mallards acquire nutrient reserves in central Iowa, 2) compare this information with studies conducted on the breeding and wintering grounds, and 3) show what influence age, reproductive condition, and molt have on nutrient reserves dynamics.

METHODS

This study was conducted in central Iowa within a 50-km radius of Ames, in Story County. Central Iowa is the southernmost extent of the Prairie Pothole Region. Small numbers of mallards nest near the few remaining emergent wetlands, but the number is miniscule compared with the numbers that migrate through the area. Few mallards are known to overwinter in Story County. Numerous cropland basins, planted primarily to corn (*Zea mays*) and soybeans (*Glycine max*), fill with melt and rainwater in the spring and are extensively used by spring migratory waterfowl (see Section II).

A total of 15 and 28 paired hen mallards were shot while using seasonally-flooded agricultural ponds during the spring migrations of 1983 and 1984, respectively. A drake and hen staying and moving together or exhibiting pair behavior (Jorde 1981) for a 5-minute period were considered paired. In 1984, collections were divided into the premigratory peak (early), migratory peak (peak), and postmigratory peak (late) periods as determined from counts during a roadside survey (Appendix A).

Collected birds were field-weighed to the nearest 10 g with a Homs tubular spring scale. The contents of the esophagus, proventriculus, and gizzard were immediately removed and used for another study. The organs were replaced in the carcass, and the birds were double-bagged and frozen at -20 degrees C.

Total body weight (wet) of the birds was measured to the nearest 0.1 g after thawing. Total body length, exposed culmen, tarsus, keel, and wing chord were all measured to the nearest 0.5 mm. Prebasic molt was scored by estimating percentage incoming contour feathers on 20 separate body regions and estimating percentage new down over the entire body. Feathers were plucked, and the following were removed and weighed wet to the nearest 0.01 g: breast muscle (pectoralis and supracoracoideus) leg muscle (originating from or inserting to the femur, tibula, and fibula), gizzard, heart, liver, ovary, and oviduct. Birds were aged by presence or absence of a bursa (Hochbaum 1942). The eviscerated carcass (carcass less the gastrointestinal tract, heart, liver, kidneys, reproductive tract, and feet distal to the tibiotarsus) was weighed wet to the nearest 0.1 g, double-bagged, and refrozen at -20 degrees C.

The eviscerated carcass was partially thawed and homogenized in a Hobart food processor. Two randomly selected tissue subsamples were placed into preweighed petri dishes and weighed to the nearest 0.01 g. Subsamples were freeze-dried for 120 h and then reweighed to determine tissue moisture content. A 20-g aliquot was selected from each dried subsample and extracted for 22 h by the Soxhlet process using petroleum ether (Horwitz 1975). Extracted aliquots were oven-dried at 55 degrees C for 24 h and weighed to the nearest 0.01 g. The extracted aliquot was fat-free dry weight plus ash and was used as an index of protein reserves.

Differences between paired means were tested by analysis of variance (ANOVA). Multiple comparisons were made by using the least significant difference (LSD) test (Ray 1982). All comparisons were made at the $P \leq 0.05$ significance level.

Temperature and precipitation data for 1983 and 1984 were obtained for Ames, Colo, and Zearing, Iowa from the U.S. Dept. of Commerce (1983, 1984).

RESULTS

Migration Chronology and Weather

In 1983, mallards arrived in central Iowa during the third week of February, earlier than average (Dinsmore et al. 1984). Birds were collected between 8 March and 9 April. Precipitation throughout the migratory period averaged 3.0 cm above normal. Temperatures were 3.5 degrees C above normal in February, 1.0 degrees C above normal in March, and 3.4 degrees C below normal in April.

In 1984, spring migratory mallards again arrived in central Iowa during the third week of February. Collections were divided into the early (23 February - 4 March), peak (24 - 30 March), and late (9 - 17 April) periods. Precipitation throughout the migratory period averaged 6.1 cm above normal. Temperatures were 5.6 degrees C above normal in February, 2.9 degrees C below normal in March, and 1.0 degrees below normal in April.

Nutrient Reserves Dynamics

There were no significant year-to-year differences in any of the weights measured (Table 1). Body and carcass constituent weights were not different between juveniles (birds hatched the previous year) and adults in 1983, but in 1984, adults had significantly greater water and fat-free dry weights than did juveniles (Table 2).

No significant differences were found in water and fat-free dry weights between the three 1984 migratory periods (Table 3). Field-measured and corrected body weights were significantly greater during the late period than during the peak period. Eviscerated carcass weights and lipid weights were significantly greater during the late peak period than during either of the two earlier periods.

Weight changes of certain body organs and muscles are known to reflect body protein changes (Ankney 1977) or changes in food habits (Ankney 1977, Drobney 1984). The only significant change for five body organs and two muscles between the three 1984 migratory periods was the increase of small intestine weights (Table 4).

Table 1. Mean body and carcass constituent weights (g) for paired hen mallards in 1983 and 1984

Weights	1983 Mean±SE (n)	P	1984 Mean±SE (n)
Field-measured body	1166.7±20.8 (15)	NS[a]	1119.3±26.3 (28)
Corrected body[b]	1140.4±23.6 (11)	NS	1062.3±24.5 (25)
Eviscerated carcass[c]	850.0±19.1 (15)	NS	807.4±19.3 (28)
Water	485.5±6.3 (15)	NS	486.3±7.5 (28)
Lipid	155.8±14.5 (15)	NS	115.4±14.3 (28)
Fat-free dry	208.7±3.6 (15)	NS	205.7±3.2 (28)

a (ANOVA) ($P \leq 0.05$).
b Gastrointestinal contents removed.
c See methods for description.

Table 2. Mean body and carcass constituent weights (g) for juvenile and adult paired hen mallards in 1983 and 1984

	1983			1984		
Weights	Juvenile Mean±SE (N)	p	Adult Mean±SE (N)	Juvenile Mean±SE (N)	p	Adult Mean±SE (N)
Field-measured body	1142.9±25.4 (7)	NS	1187.5±31.7 (8)	1105.0±34.3 (14)	NS	1133.6±40.8 (14)
Corrected body	1119.4±29.7 (5)	NS	1157.9±36.2 (6)	1043.5±30.3 (13)	NS	1082.7±39.6 (12)
Eviscerated carcass	852.8±23.8 (7)	NS	847.5±30.7 (8)	787.9±25.0 (14)	NS	827.0±29.5 (14)
Water	483.7±7.3 (7)	NS	487.1±10.5 (8)	467.8±10.4 (14)	0.010	504.8±8.5 (14)
Lipid	158.2±20.0 (7)	NS	153.8±22.1 (8)	120.9±16.7 (14)	NS	109.9±23.8 (14)
Fat-free dry	210.9±6.7 (7)	NS	206.7±3.8 (8)	199.1±5.0 (14)	0.039	212.3±3.3 (14)

Table 3. Mean body and carcass constituent weights (g) for paired hen mallards for three migratory periods in 1984

Weights	Early Mean±SE (N)	Peak Mean±SE (N)	Late Mean±SE (N)
Field-measured body	1075.7±32.0 (7) AB[a]	1051.1±30.1 (9) B	1195.8±46.8 (12) A
Corrected body	1031.7±23.3 (5) AB	998.9±26.7 (9) B	1128.1±43.6 (11) A
Eviscerated body	784.2±15.6 (7) A	738.7±20.1 (9) A	872.5±33.3 (12) B
Water	506.7±10.1 (7) A	478.2±13.6 (9) A	480.5±12.5 (12) A
Lipid	69.4±11.6 (7) A	58.0±8.7 (9) A	185.4±17.6 (12) B
Fat-free dry	208.2±5.2 (7) A	202.5±5.3 (9) A	206.7±5.9 (12) A

[a] Least significant different tests, shared letters indicate no significant ($P \leq 0.05$) difference.

Table 4. Mean body organ and muscle weights (g) of paired hen mallards for three migratory periods in 1984

	Early	Peak	Late
Weights	Mean±SE (N)	Mean±SE (N)	Mean±SE (N)
Gizzard	45.8±2.6 (7) A[a]	37.9±2.8 (9) A	40.4±2.8 (11) A
Small Intestine	18.7±0.7 (7) A	19.8±0.4 (9) AB	21.4±0.8 (12) B
Large Intestine	2.5±0.2 (7) A	2.3±0.1 (9) A	2.2±0.1 (12) A
Liver	25.6±4.0 (7) A	33.3±3.8 (9) A	31.2±1.9 (12) A
Heart	12.8±0.4 (7) A	12.3±0.6 (9) A	12.4±0.4 (12) A
Breast Muscle	121.2±2.4 (7) A	118.6±3.8 (9) A	123.8±4.0 (12) A
Leg Muscle	34.1±1.7 (6) A	31.8±1.6 (9) A	33.7±1.2 (12) A

[a] See Table 3.

Reproductive Condition

In both years, ovary weights in adults were greater than in juveniles (Table 5). This difference was significant in 1984. Ovary and lipid weights increased rapidly as the 1984 migration progressed (Figure 1). Ovary weights were significantly greater during the late period than during the early period (Table 6).

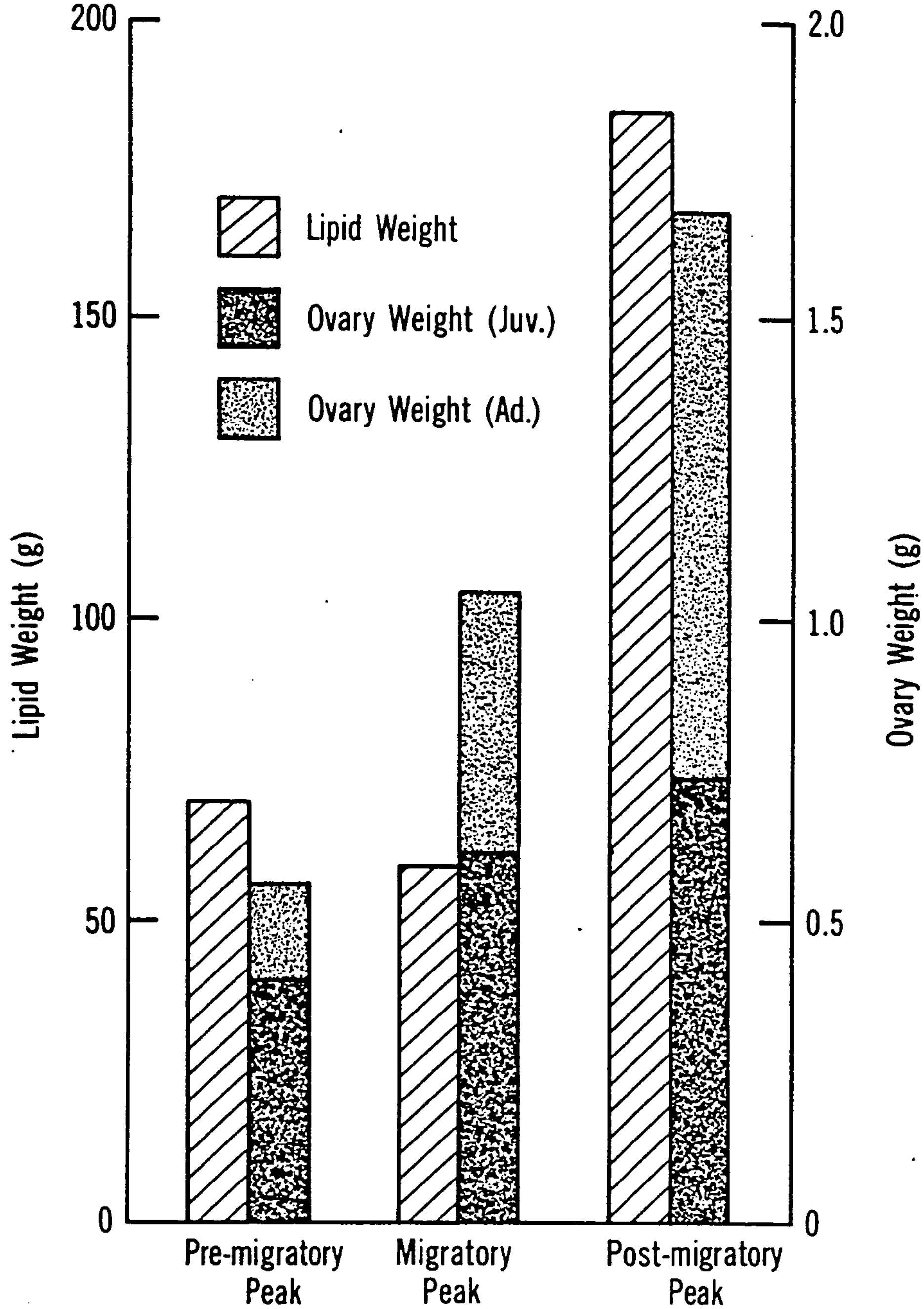
Prebasic Molt

No significant differences in percentage of incoming contour feathers between age groups were detected (Table 5). In 1984, adults had a significantly greater percentage of new (black) down than did juveniles (Table 5). Percentage of new down did not differ between the three migratory periods (Table 6). The percentage of incoming contour feathers was significantly less during the late period than during the peak period (Table 6).

Table 5. Mean ovary weights (g) and extent of prebasic molt (%) for juvenile and adult paired hen mallards in 1983 and 1984

	1983			1984		
	Juvenile		Adult	Juvenile		Adult
	Mean±SE (N)	p	Mean±SE (N)	Mean±SE (N)	p	Mean±SE (N)
Ovary weight	0.49±0.11 (7)	NS	0.72±0.09 (8)	0.64±0.06 (14)	0.010	1.10±0.15 (14)
Incoming contour feathers	14±3.2 (7)	NS	13±2.1 (8)	9±1.7 (14)	NS	10±1.8 (14)
New (black) down	54±0.1 (6)	NS	65±13.2(8)	42±7.7 (14)	0.009	70±6.4 (14)

Figure 1. Comparison of paired hen mallard lipid and ovary weights by spring migratory periods



200
150
100
50
0
2.0
1.5
1.0
0.5
0
Lipid Weight
Ovary Weight (Juv.)
Ovary Weight (Ad.)
Lipid Weight (g)
Ovary Weight (g)
Pre-migratory Peak
Migratory Peak
Post-migratory Peak

Table 6. Mean ovary weights (g) and extent of prebasic molt (%) for paired hen mallards for three migratory periods in 1984

	Early	Peak	Late
	Mean±SE (N)	Mean±SE (N)	Mean±SE (N)
Ovary weight	0.51±0.04 (7) A[a]	0.81±0.12 (9) AB	1.13±0.16 (12) B
Incoming contour feathers	12±2.3 (7) AB	13±2.7 (9) B	6±0.9 (12) A
New (black) down	44±14.8 (7) A	64±6.4 (9) A	56±8.8 (12) A

[a] See Table 3.

DISCUSSION

Weight and Lipid Dynamics

Average weights of paired hen mallards, of both age classes, I collected during spring migration were greater than average weights recorded on the wintering grounds in January and/or February in Arkansas (Wright 1960), Czechoslovakia (Folk et al. 1966), Alberta (Sugden et al. 1974), Britain (Owen and Cook 1977), Oklahoma (Gordon 1981), Nebraska (Jorde 1981), and Texas (Whyte and Bolen 1984a). The information was better compared when the spring migration was divided into three migratory periods. Mallards that I collected during the early and peak periods weighed slightly more than mallards on the wintering grounds in January and/or February (Folk et al. 1966, Owen and Cook 1977, Gordon 1981, Jorde 1981) and slightly less than mallards on the high plains of Texas (Whyte and Bolen 1984a). Mallards that were collected during the late period weighed substantially more than birds on the wintering grounds in any of the studies just mentioned.

Spring migratory mallards were, on the average, slightly lighter than birds collected on arrival at the North Dakota breeding grounds (Krapu and Doty 1979, Krapu 1981). When the Iowa collections were divided into migratory periods, it was evident that hen mallards do not reach breeding weights in the two earliest migratory periods. But by the final migratory period, the birds had attained weights equivalent to those of birds arriving on the breeding grounds (Krapu and Doty 1979, Krapu 1981).

Few researchers have investigated lipid dynamics of wintering mallards, and extraction methodologies, geographic locations, and years vary, making comparisons and interpretation difficult. Average lipid weights of spring migratory mallards collected in Iowa were less than average lipid weights of wintering mallards (Jorde 1981, Whyte and Bolen 1984a). When examined by migratory periods, though, it was evident that, during the first two migratory periods, mallards carried less than 50% the lipid weight that birds carried in Nebraska (Jorde 1981) and Texas (Whyte and Bolen 1984a), respectively. But by the final migratory period, Iowa-collected birds were fatter than mallards collected by Jorde (1981) and fatter than birds collected by Whyte and Bolen (1984a) during all winter periods except their midwinter period.

Mallards that I collected during the first two migratory periods were less fat than mallards collected on arrival at the breeding grounds (Krapu and Doty 1979, Krapu 1981). But in the final migratory period, mallards in Iowa had acquired equivalent or greater lipid reserves than those arriving at the breeding grounds.

Possible Strategies for Weight and Lipid Gains

Comparisons of body and lipid weights of spring migratory hen mallards with those on the wintering and breeding grounds show that mallards are gaining weight and putting on lipid reserves during the spring migration and that these gains occurred late in the migration (April) in Iowa. These gains are occurring during the period of the annual cycle when a paired hen mallard is undergoing a variety of energy-requiring activities, including the migratory flight (Prince 1979), gonadal growth (Johnson 1961, Ricklefs 1974, this study), pair bond maintenance (King 1974), and prebasic molt (Jorde 1981, this study). It is also a time of year when the costs of thermoregulation (Prince 1979) can be high because of brief, but intense, periods of cold. So it must be to a mallard's ultimate advantage, not only to meet these energetic costs, but, in addition, to put on substantial lipid reserves.

There are several possible advantages to mallards acquiring lipid reserves during the spring migration. One possible advantage would be that the reserves attained during a migratory stopover are used as an energy source during the next migratory flight, as has been suggested for Canada Geese (Raveling 1979). A second possible advantage would be to accumulate a reserve of lipids to be used to meet existence energy requirements during periods of inclement spring weather and corresponding periods of food scarcity. The subcutaneous lipids could also act as insulation (Raveling 1979). Jorde (1981) and Whyte and Bolen (1984b) found that a wintering mallard's energy balance was adversely affected by inclement weather. In addition, mallards acquired lipid reserves during periods of mild winter weather between storms (Whyte and Bolen 1984b). It would be advantageous for migrants to add lipid reserves during periods of favorable weather and food supply, to be used when environmental conditions deteriorate either during migration or on the breeding grounds. A third possible advantage would be for the hen mallard to acquire lipid reserves during spring migration and then expend these reserves on the breeding grounds in search of invertebrates (Swanson et al. 1979) used for the exogenous protein required to produce the first clutch (Krapu 1981). Invertebrates are potentially more difficult to capture and are of less caloric value (Driver et al. 1974) than are most other waterfowl foods (i.e., seeds). Finally, lipid reserves acquired during the spring migration may be catabolized for the growth of the ovary and oviduct and the production of a clutch of eggs. It is doubtful, however, that the relatively small lipid requirement (Drobney 1980) of this growth adequately explains the magnitude of the lipid reserves acquired during spring. Most likely, the ultimate strategy is that of the lipid reserves used during the next migratory flight, stored as a "hedge" against inclement weather and, finally, providing an energy source that allows the hen to switch to invertebrate foraging upon arrival at the breeding grounds.

If it is to the ultimate advantage of migrants to acquire substantial lipid reserves, then why did the birds collected during this study gain these reserves during the late period? Possibly it is because temperatures were below normal in March, and a greater than average amount of energy was expended on thermoregulation during the peak period, thereby preventing a buildup of reserves. Conversely, weather conditions were more favorable later in the spring, which could account for the weight and lipid gains in the final migratory period. Another possibility is that it is energetically more efficient to keep wing loading low to reduce flying costs (Pennycuick 1969). This is less likely because weight gains for other bird species actually begin before departure (King and Farner 1965, Wypkema and Ankney 1979, McLandress and Raveling 1981a). A third possibility is that mallards collected during the final migratory period were closer to nest initiation (see Fig. 1). The closer in time that a hen mallard is to nesting, the more reserves she is likely to carry to meet the demands of nesting. Raveling (1979) predicted that Canada geese were most likely to attain maximum weight within a 2-week period before their departure from their last spring staging area. A final possibility, that of unknown arrival date, will be discussed in greater detail later.

Several factors, acting together, allow for the spring migration to be a time of favorable energy balance for paired hen mallards moving through Iowa and, likely, other midwestern states. The fairly abundant precipitation, along with melting snow, creates numerous seasonally-flooded habitats that contain high-energy foods (corn, moist-soil plant seeds, and tubers) that are heavily utilized by paired hen mallards (Appendix B). The spring migratory period is also a time when many bird species, including mallards (Appendix C), become hyperphagic (King and Farner 1965, Wypkema and Ankney 1979, McLandress and Raveling 1981b). In addition, the paired hen has the advantage of being able to spend a relatively greater portion of her time feeding while the drake remains alert and defends the foraging site (Jorde 1981). Finally, continental mallard populations reach seasonal lows before the spring hatching period. Consequently, there should be less competition for available food resources and foraging sites.

Age-related Aspects

It was of interest that body and lipid weights of juvenile and adult spring migratory mallards were not significantly different. The results of other mallard studies have varied. Juvenile mallards weighed less than adults in fall (Bellrose and Hawkins 1947) and in December, January, and February but not in November or March (Owen and Cook 1977). Juvenile hen mallards were lighter than adults in January-February (Gordon 1981). On the high plains of Texas, juveniles had lighter body and lipid weights than adults during all winter periods (Whyte and Bolen 1984a). But juveniles were heavier and carried more lipid reserves than did adults during the winter and early spring in Nebraska (Jorde 1981). Upon arrival at the breeding grounds, juvenile hens were lighter and carried less lipid reserves than adults (Krapu and Doty 1979). So it seems that, in certain years, geographic locations, and times of year, juveniles can equal or even exceed adult body and lipid weights. That this was the case for both 1983 and 1984 in Iowa can be explained partly by the fact that collected birds of both age classes were paired. In addition, juvenile mallards on the spring migration have survived the brood period, fall migration and hunting season, and winter. Such birds are likely to be healthy, experienced, and able to add reserves at a rate equal to their adult counterparts. More research is needed into these age-related factors, including what factors can cause juveniles to be lighter in weight and lower in lipid reserves than adults upon arrival at the breeding grounds, at least in some years.

Protein Reserves

The lack of significant changes in hen mallard protein reserves during the spring migration conforms closely with winter studies (Jorde 1981, Whyte and Bolen 1984a). On the breeding grounds, Krapu (1981) found that protein reserves varied little between arrival, laying, and incubation. Therefore, hen mallards do not acquire large reserves of protein during the spring migration as has been suggested for other waterfowl (Milne 1976, Ankney and MacInnes 1978, Peterson and Ellarson 1979, Raveling 1979) and do not use substantial endogenous protein reserves to produce a clutch (Krapu 1981). The slight changes that do occur are more likely due to changes in food habits than to storage or catabolization of reserves (Jorde 1981, Krapu 1981).

Interpretation Problems

Two overriding factors make the interpretation of spring migratory waterfowl energetics work very difficult. First, the past histories of collected individuals are not known. Where a bird spent the winter and where it will nest could have a significant influence on the bird's nutrient reserves status as it migrates. This is a particularly severe problem when working with mallards because their breeding and wintering ranges encompass a vast latitudinal range (Bellrose 1980). To minimize this problem, spring migratory mallards should be collected only where the number of wintering and breeding mallards is minimal (e.g., central Iowa). The second major problem is that turnover time of mallards on the spring migratory grounds is unknown. The date a bird arrives at the collection location and how long the bird stays in the area will affect its nutrient reserves. A bird collected the day it arrives on the spring migratory area may have depleted lipid reserves, whereas a bird that has been foraging on the area for several days likely will have regained lipid reserves (Cherry 1982). One possible remedy is to collect only known (marked) individuals, a complex logistical problem during the spring migration for a species as numerous and dispersed as the mallard. The alternative is to collect birds over a number of days and assume that, if sample sizes are sufficient, the unknown turnover time problems will be reduced. Further work is needed on these problems before we can fully understand the annual nutrient reserves dynamics of the North American mallard population.

MANAGEMENT IMPLICATIONS

The implications of failing to meet the the energetic needs of spring migratory mallards are manyfold. It is possible that hen mallard mortality could increase either through starvation (Jordan 1953) or decreased physical condition and the subsequent increased risks of predation or disease. I did not observe that these were major problems for spring migrants in central Iowa. A potentially more serious problem is the sublethal effects of not meeting the energetic requirements of spring migratory mallards. A positive relationship between lipid reserves and clutch size has been shown for common eiders (Somateria mollissima) (Milne 1976), snow geese (Ankney and MacInnes 1978), Canada geese (Raveling 1979), and mallards (Krapu 1981). It also has been shown that captive mallards reduce clutch size when diet, especially protein (Krapu 1979), is restricted (Batt and Prince 1979) and that clutch size in wild prairie ducks is limited by the amount of exogenous protein and lipid reserves available to the hen (Krapu 1981, Rohwer 1984). It is possible, then, that failure to meet a hen mallard's energetic needs, including acquiring reserves, during spring migration will result in reduced recruitment to the North American mallard population.

To insure that the needs of spring migrants are met, it is necessary to provide adequate habitat in the appropriate geographic locations. The results of this study and others (see Section II) suggest that habitats that provide a diversity of high energy and nutritious food resources are needed. Moist-soil areas (Fredrickson and Taylor 1982) and the vegetatively similar seasonally-flooded agricultural ponds can provide such resources. It is important to provide these habitats throughout the spring migratory range of the mallard, especially where these habitats are near the breeding grounds.

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SECTION II. HABITAT USE BY SPRING MIGRATORY MALLARDS IN CENTRAL IOWA

ABSTRACT

The spring migratory period, during which hens acquire lipid reserves, is potentially critical in the annual cycle of mallards (<u>Anas platyrhynchos</u>). Failure to meet the needs of spring migrants could affect recruitment to the North American mallard population. Past spring studies have failed to investigate habitat use by migratory mallards, information critical to properly manage for spring migratory mallards. A 97 km roadside survey of 455 seasonally-flooded agricultural ponds (sheetwater) and 16 small emergent wetlands was driven at three-day intervals during the 1983 and 1984 spring migrations. Ponds were classed by size, residual crop or vegetation from the previous growing season, tillage type, and distance from the nearest road and farmstead. Migratory mallards used larger (> 2 ha) ponds more than smaller ponds, moist-soil and corn ponds more than emergent wetlands or soybean ponds, untilled ponds more than conservation-tilled or plowed ponds, and ponds located further from disturbance. Sheetwater ponds provided 20,209 mallard use days during the 1983 and 1984 migrations, compared to 103 provided by the few remaining emergent wetlands. Sheetwater was used during all daylight hours, but the birds flew up to 13 km to spend the night on larger emergent wetlands. It is important to provide a diversity of habitats for spring migratory mallards; sheetwater or moist-soil impoundments containing numerous high-energy and

nutritious seeds for use during daylight hours, and emergent wetlands for use during nighttime. Preventing further loss of these habitats is critical to reduce long-term detrimental impact to the North American mallard population.

INTRODUCTION

In the past 50 years, research on waterfowl breeding ecology has expanded vastly, enabling waterfowl managers to undertake intensive programs for the betterment of North America's waterfowl populations. Much of this work assumed that conditions on the breeding grounds were population limiting (Pospahala et al. 1974). There have been suggestions that the scarcity of breeding mallards (Trauger and Stoudt 1978) and other birds (Fretwell 1972) may be due to factors away from the breeding grounds. It has been suggested that mallard recruitment is influenced by habitat conditions on the wintering grounds (Heitmeyer and Fredrickson 1981) and by female lipid reserves acquired prior to arrival on the breeding grounds (Krapu 1981, Section I). In response to this broader view of the annual cycle and its effect on North American waterfowl populations, there has been a proliferation of postbreeding and wintering waterfowl studies.

The spring migratory period has remained a major gap in our knowledge of the annual cycle of waterfowl. The few studies of mallards conducted during spring have concentrated on orientation, migratory pathways, and migration chronology (Bellrose 1980). Conservation agencies cannot properly manage for mallards during the spring migration without adequate knowledge of the habitats used. Failure to meet the habitat needs of spring migrants, combined with continuing losses of emergent wetlands (Bishop 1981, Weller 1981) and seasonally-flooded agricultural ponds (Anonymous 1983a) in central North America, must ultimately affect waterfowl populations.

The objectives of this paper are to 1) identify habitats used by spring migratory mallards in central Iowa, and 2) discuss the characteristics of those habitats that influenced mallard use. This information should allow resource managers to better meet the needs of spring migratory waterfowl.

STUDY AREA

This study was conducted in central Iowa within a 50 km radius of Ames, in Story County. The area is the southernmost extent of the Prairie Pothole Region. Story County has lost over 98% of its emergent wetlands due to drainage and development (Anderson 1974), and currently has about one emergent wetland per 50 square miles. A few mallards and blue-winged teal (_Anas discors_) nest near the remaining wetlands, but the number is miniscule compared to the numbers that migrate through the area in spring. Few mallards overwinter in Story County.

Most of the basins that were formerly wetlands are now planted to corn (_Zea mays_) or soybeans (_Glycine max_) but still fill with melt and rain water in the spring. These seasonally-flooded agricultural lands will be referred to as sheetwater ponds. These ponds rarely exceed 40 cm in depth, and many were tiled, allowing for rapid removal of surface water. In some basins the crop failed, due to drowning or herbicide failure, and moist-soil vegetation (see Fredrickson and Taylor 1982) developed, dominated by _Ammaranthus_ sp., _Cyperus_ sp., _Leersia_ sp., _Polygonum_ sp., _Rorippa_ sp., _Rumex_ sp., _Setaria_ sp., and others. In 1983, the payment-in-kind (PIK) program (Anonymous 1983b) idled up to 50% of the study area's corn hectarage. The idled lands were planted to a cover crop, such as a mixture of alfalfa or smooth brome (Rod Bienson, Story Co. Agricultural Stabilization and Conservation Service (ASCS), pers. comm.), and basins in these areas often contained numerous moist-soil plants. PIK lands were available for waterfowl use only during the spring of 1984. Tillage of croplands in central Iowa commences, as the weather allows, after the crop is harvested (October, November), and again in late spring when the ground dries.

METHODS

A 97 km roadside survey route that maximized the number of sheetwater ponds seen per unit distance was established in 1983 (Appendix D). The route was driven at 3-day intervals, each run beginning at a randomly selected location. The route was begun at least 1.5 hours after sunrise and always was completed by sunset on the same day.

All ponds not frozen and larger than 0.02 ha were considered usable by waterfowl and were monitored. Any pond clearly visible from the road, usually within 0.5 km, was monitored. As the route was driven, every usable pond was checked for birds by using a 15-45x spotting scope. All waterfowl using a pond along the route were counted by species and sex. Five variables were recorded for all ponds monitored.

1) Each time the survey was conducted, pond size was visually estimated to the nearest 0.1 ha, relative to maximum pond size. The maximum pond size was measured from ASCS aerial color slides with a digital planimeter.

2) Linear distance (m) from the center of the nearest road to the center of the pond was measured from ASCS aerial color slides.

3) Linear distance (m) from the center of the nearest farmstead to the center of the pond was measured from ASCS color slides.

4) Vegetation from the previous growing season was

identified for the pond basin (portion flooded > 75% of the time) and the periphery of the pond (portion flooded $\leq$ 75% of the time). The eight basin/peripheral vegetation combinations monitored were corn/corn, soybeans/soybeans, moist-soil/moist-soil, PIK/PIK, emergent/emergent (i.e., dominated by emergent wetland plants), moist-soil/corn, moist-soil/soybeans, and moist-soil/PIK.

5) Tillage patterns for the basin and periphery were identified as none, conservation tilled, or plowed. Conservation-tilled fields or ponds were worked with conservation or minimum tillage equipment that left some vegetative residue on the soil surface. Moldboard-plowed fields or ponds contained essentially no residue on the soil surface. The five basin/peripheral fall tillage combinations monitored were none/none, conservation/conservation, plowed/plowed, none/conservation, and none/plowed.

In 1984, a separate emergent wetland survey route was established to increase the sample of emergent wetlands (only 4 existed along the original survey route). Twelve additional wetlands were monitored every 6 days, following similar procedures used for the original survey route.

All mallard count data were log transformed to meet the statistical assumption of additivity (Steel and Torrie 1980). To meet the statistical assumption of indepedence (Steel and Torrie 1980), analyses were performed on the average number of mallards (transformed) counted per pond during the migratory season.

The relationship of pond size, distance from road, and distance from farmstead, to mallard numbers was analyzed by simple linear regression. The relationship of tillage and vegetation types, to mallard numbers was analyzed using a multiple regression model containing all independent variables. Because emergent wetlands received no tillage treatment, they could not be included in the multiple regression model. To include the emergent wetlands in the analysis, I also analyzed the vegetation data by use of analysis of covariance with pond size as the covariate. All multiple range comparisons between the least-square means (LSMEANS) were made using the probability of a significant difference (PDIFF) test (Ray 1982). All tests were made at the $P \leq 0.05$ significance level.

Temperature and precipitation data for 1983 and 1984 were obtained for Ames, Colo, and Zearing, Iowa from the U.S. Dept. of Commerce (1983, 1984).

RESULTS

Migration Chronology and Weather

In 1983, mallards arrived in central Iowa during the third week of February, earlier than average (Dinsmore et al. 1984). Mallard populations peaked at 1,608 along the route on 18 March, and fell to consistently fewer than 40 birds after 19 April (Appendix A). The route was travelled 16 times between the arrival of migrants and the end of the migration (i.e., when the number of mallards along the route was fewer than 40). Total precipitation throughout the migratory period was 3.0 cm above normal. Temperatures were 3.5 degrees C above normal in February, 1.0 degrees C above normal in March, and 3.4 degrees C below normal in April.

In 1984, spring migratory mallards again arrived in central Iowa during the third week of February. Populations peaked at 1,338 mallards along the route on 26 March and fell to fewer than 40 mallards after 16 April (Appendix A). The route was travelled 13 times. Total precipitation throughout the migratory period was 6.1 cm above normal. Temperatures were 5.6 degrees C above normal in February, 2.9 degrees C below normal in March, and 1.0 degrees C below normal in April.

Pond Dynamics and Characteristics

The number of sheetwater ponds along the survey route changed dramatically over a period of a few days (Fig. 1). Some ponds shrank from 5 ha to dry in 2 days. The total number of ponds was closely related to precipitation, increasing rapidly after a heavy rain and more gradually after a heavy snow (Fig. 1). Pond numbers sometimes declined after a snowfall and only began to rise after the snow melted. Pond numbers were also influenced by basin hydrology, tile systems, frozen soils, and tillage.

Several independent variables were related to pond size. For example, there was a positive relationship (R-square=0.05, P=0.0001) between pond size and distance from the nearest road. This was likely because larger ponds were more visible from the road. In turn, vegetation and tillage treatments were influenced by pond size (Table 1). The moist-soil/moist-soil ponds were the largest followed by emergent wetlands, while the smallest ponds were usually planted to corn or soybeans. Ponds that were not tilled in the basin but were plowed around the periphery were the largest, and conservation/conservation and plowed/plowed ponds were the smallest. Finally, there was a relationship between vegetation and tillage treatment (Table 2). Moist-soil ponds received the least tillage followed by soybean ponds. PIK and corn ponds received the most tillage.

Figure 1. Relationship between the number of ponds along the survey route, precipitation, and date. Shading indicates periods of snowfall

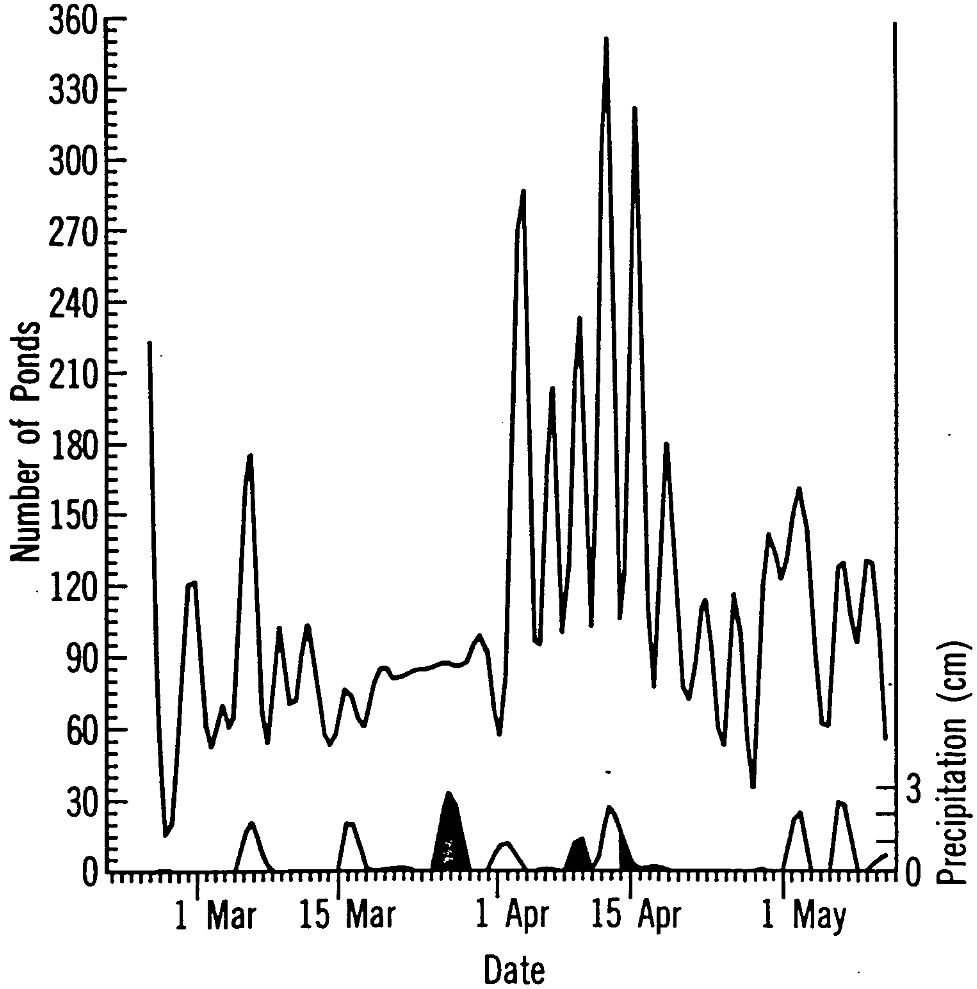
Number of Ponds
360
330
300
270
240
210
180
150
120
90
60
30
0
Precipitation (cm)
3
0
1 Mar
15 Mar
1 Apr
15 Apr
1 May
Date

Table 1. Mean pond size for each vegetation and tillage type

Vegetation (basin/periphery)	Size (ha)	Tillage (basin/periphery)	Size (ha)
Moist-soil/moist-soil	1.8	None/plowed	1.4
Emergent/emergent	1.6	None/none	0.7
Moist-soil/PIK	1.2	None/conservation	0.7
Moist-soil/corn	1.1	Conservation/conservation	0.5
PIK/PIK	0.8	Plowed/plowed	0.5
Moist-soil/soybean	0.7		
Corn/corn	0.4		
Soybean/soybean	0.4		

Table 2. Percentage of tillage type for ponds of each vegetation type

Vegetation (basin/periphery)	Tillage (basin/periphery)				
	None/ none	None/ conservation	None/ plowed	Conservation/ conservation	Plowed/ plowed
Corn/corn	35.8	6.1	1.4	43.9	12.8
Soybeans/soybeans	77.8	Ø.Ø	Ø.7	19.4	2.1
Moist-soil/ moist-soil	1ØØ.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø
Moist-soil/corn	55.6	11.1	1Ø.1	18.2	5.1
Moist-soil/ soybeans	95.1	Ø.6	1.6	2.2	Ø.6
Moist-soil/PIK	47.4	15.8	21.1	15.8	Ø.Ø
PIK/PIK	34.4	3.1	1.Ø	37.5	24.Ø

Year-to-Year Differences

The 1983 and 1984 migrations were similar in many respects. Both were characterized by above normal precipitation and an earlier than normal migration. The 1983 migration was more extended and consequently more mallards were counted along the route (6,437 in 1983 vs. 3,361 in 1984). In general, in both years, emergent wetlands or ponds vegetated with some combination of moist-soil plants, corn, or PIK received the greatest use, as did ponds that were not tilled or were conservation-tilled (Tables 3 and 4). Interpretation of these differences was complicated by changing sample sizes between years, the uncontrolled planting and tillage decisions made by farmers each year, and the addition of PIK ponds and the emergent wetland survey in 1984. For instance, many ponds that were moist-soil in 1983 were placed into the PIK program, contributing to the greatly decreased use of moist-soil/moist-soil ponds in 1984. The year-to-year differences were considered minor and therefore, all analyses were performed on 1983/1984 combined data (Tables 3 and 4).

Influence of Pond Size and Disturbance

The highly significant ($P=0.0001$) relationship ($Y=0.01+0.14X$) between mallard use of a pond and pond size explained a moderate portion ($R\text{-square}=0.22$) of the variation

Table 3. Mean number of mallards per pond per migratory season for 1983 and 1984 classed by vegetation type

Vegetation (basin/periphery)	1983 Mean ± SE (N)	1984 Mean ± SE (N)	Both years combined Mean ± SE (N)
Moist-soil/ moist soil	9.25 ± 8.18 (10)	0.03 ± 0.03 (6)	5.79 ± 5.14 (16)
Moist-soil/corn	1.28 ± 0.60 (62)	5.60 ± 2.69 (40)	2.98 ± 1.13 (102)
Emergent/emergent	0.51 ± 0.28 (4)	1.69 ± 0.69 (16)	1.46 ± 0.56 (20)
Corn/corn	1.88 ± 1.03 (93)	0.48 ± 0.35 (83)	1.22 ± 0.57 (176)
Moist-soil/PIK	NA	1.12 ± 0.58 (23)	1.12 ± 0.58 (23)
PIK/PIK	NA	0.38 ± 0.22 (124)	0.38 ± 0.56 (124)
Moist-soil/ soybeans	0.50 ± 0.23 (110)	0.07 ± 0.04 (96)	0.30 ± 0.13 (206)
Soybeans/soybeans	0.01 ± 0.01 (83)	0.09 ± 0.09 (83)	0.05 ± 0.05 (166)

Table 4. Mean number of mallards per pond per migratory season for 1983 and 1984 classed by tillage type

Tillage (basin/periphery)	1983 Mean ± SE (N)	1984 Mean ± SE (N)	Both years combined Mean ± SE (N)
None/none	1.33 ± 0.46 (288)	0.88 ± 0.26 (248)	1.12 ± 0.28 (536)
Conservation/conservation	0.28 ± 0.28 (49)	1.12 ± 0.71 (142)	0.90 ± 0.53 (191)
None/plowed	0.29 ± 0.28 (12)	0.89 ± 0.89 (9)	0.56 ± 0.40 (21)
None/conservation	0.40 ± 0.30 (16)	0.42 ± 0.42 (14)	0.41 ± 0.25 (30)
Plowed/plowed	0.04 ± 0.04 (9)	0.00 ± 0.00 (60)	0.01 ± 0.01 (69)

in mallard use. The distance of a pond from the nearest road also explained some variation in mallard use (R-square=0.10) with the relationship being positive and highly significant (P=0.0001). There was no significant (P=0.11) relationship between mallard use of a pond and its distance from the nearest farmstead.

Influence of Tillage and Vegetation Type

There were differences in mallard use due to tillage treatment (Table 5). Ponds not tilled on the basin or periphery received significantly greater use than plowed/plowed ponds and nontilled/plowed ponds. When only the peripheral tillage was considered, a clear trend became evident. Ponds not tilled on the periphery were used most, followed by conservation tilled ponds. Plowed ponds received the least use.

The multiple regression analysis of the relationships between mallard use and vegetation types showed a trend of moist-soil, corn, or PIK ponds receiving the greatest use, and soybean ponds receiving the least use (Table 6). Again, this trend is more evident when only the peripheral vegetation is considered. When the emergent wetlands were added in the analysis of covariance, the trends in the least-square means for the agricultural ponds remain unchanged except for the place change between corn/corn and moist-soil/corn ponds.

Table 5. Multiple regression analysis of mallard use of ponds classed by tillage type

Tillage (basin/periphery)	Least-square means
None/none	0.16 A[a]
Conservation/conservation	0.11 AB
None/conservation	0.05 AB
Plowed/plowed	0.03 B
None/plowed	-0.02 B

[a] PDIFF test, shared letters indicate no significant ($P \leq 0.05$) difference.

Table 6. Multiple regression and covariance analysis of mallard use of ponds classed by vegetation type

Vegetation (basin/periphery)	Multiple regression Least-square means	Vegetation (basin/periphery)	Analysis of covariance Least-square means
Moist-soil/ moist-soil	0.20 A[a]	Emergent/emergent	0.39 A
Moist-soil/PIK	0.12 AB	Moist-soil/ moist-soil	0.27 AB
Corn/corn	0.10 AB	Moist-soil/PIK	0.16 BC
Moist-soil/corn	0.09 AB	Moist-soil/corn	0.15 B D
PIK/PIK	0.04 BC	Corn/corn	0.14 B D
Soybeans/soybeans	-0.03 CD	PIK/PIK	0.07 CD
Moist-soil/soybeans	-0.05 D	Soybeans/soybeans	0.05 C
		Moist-soil/ soybeans	0.05 C

[a] See Table 5.

Emergent wetlands received significantly greater use than any of the other pond types monitored except moist-soil/moist-soil ponds.

The great use of emergent wetlands needs further explanation. Emergent wetlands were used 27% of the time, but the mean number of mallards using these ponds was only six. The mallards using the emergent wetlands were very likely local breeders. On the other hand, agricultural sheetwater ponds were used only 6% of the time, but the mean number of mallards using these ponds was 47. Therefore, the average sheetwater pond was used less often but was used by large flocks of migratory mallards.

The relationship between mallard use of emergent wetlands and sheetwater ponds also can be compared in absolute terms. Sheetwater ponds provided 182 and 238 times more use days than emergent wetlands during the spring migrations of 1983 and 1984 respectively (Table 7). Sheetwater habitat, in total, supported far greater numbers of spring migratory mallards in central Iowa than the few remaining emergent wetlands.

Nocturnal Habitat Use

Mallards spent all daylight hours on the sheetwater ponds, but between 64 minutes before and 26 minutes after sunset, all birds flew from one kilometer up to at least 13 km from sheetwater ponds to larger (5-100 ha) emergent wetlands and

Table 7. Mallard use days provided by ponds on survey route in 1983 and 1984 classed by vegetation type

Vegetation (basin/periphery)	1983 use days	% of use days	1984 use days	% of use days
Moist-soil/moist-soil	4,202	30	0	0
Moist-soil/corn	2,977	21	3,637	59
Corn/corn	4,921	35	486	8
Moist-soil/PIK	NA	NA	475	8
PIK/PIK	NA	NA	733	12
Moist-soil/soybeans	1,850	13	87	1
Soybeans/soybeans	11	<1	151	2
Other agricultural ponds	70	1	609	10
TOTAL AGRICULTURE	14,031	99	6,178	100
TOTAL EMERGENT WETLAND	77	1	26	<1

artificial impoundments. Between 60 minutes before and 60 minutes after sunrise, most birds departed for the sheetwater habitats.

In 1984, several qualitative nighttime observations were made with the aid of a light intensifying night vision scope. Several thousand mallards were observed using dense flooded emergent and willow (*Salix* sp.) cover as well as open water areas. A variety of activities occurred, including feeding, comfort movements, swimming, and courtship.

DISCUSSION

Several factors influenced mallard habitat use during the spring migration. One of the most important was the presence of seasonally-flooded agricultural ponds. Mallards were rarely seen feeding in the upland portions of agricultural fields, contrasting with heavy use of uplands during other times of the year (Bossenmair and Marshall 1958, Winner 1959, Sugden 1979, Thomas 1981, Baldassarre and Bolen 1984). When flooded agricultural lands were available, they were preferred over nonflooded agricultural lands (Bossenmair and Marshall 1958, Kantrud and Stewart 1977, Reed et al. 1977, Hirst and Easthope 1981, Jorde 1981). Standing water potentially could increase the availability of heavily used moist-soil plant seeds (Appendix B), increase the palatability of food items (Shearer et al. 1969), and increase the security of the mallards from land predators and disturbance.

Pond size was one of the most important sheetwater characteristics determining mallard use (Fig. 2). Large ponds are aerially visible from a greater distance. Once sighted by a migrating flock, large ponds potentially could provide more feeding sites, due to greater heterogeneity of habitats, and more space for pair segregation. Mallards using larger ponds also may "feel" more secure from predation and disturbance. Upon disturbance, mallards usually flew to the center of the pond, providing a "buffer" of open water between the disturbance factor and the birds (pers. observ.). Finally, larger ponds may be present more consistently from year to year allowing tradition (Bellrose and Crompton 1970) to play a role in the pond selection process.

Another important pond characteristic determining mallard use was vegetation. Vegetation type will primarily affect food types and, to a lesser extent, food quantity and availability, important considerations since paired hen mallards spent more time feeding than in any other activity (Appendix C). The heavy use of moist-soil, corn, and PIK ponds can be attributed to the food habits of mallards during the spring migration. Paired hen mallards collected on these habitats were feeding primarily on moist-soil plant seeds, tubers, and corn; few invertebrates and no soybeans were eaten (Appendix B). One puzzling result, that of moist-soil/soybean ponds being used the least, can be explained by considering the birds' pond selection process. If birds select these habitats from the air (Bossenmair and Marshall 1958), they would not know what the basin (flooded) vegetation was. Thus, selection is likely based on the peripheral vegetation. Ponds vegetated peripherally in moist-soil plants were used the most, followed by PIK (vegetatively similar to moist-soil ponds, see Study Area section), corn, and lastly soybeans.

Mallards used tilled, especially plowed, ponds less than ponds that were not fall-tilled. The low use of not tilled/plowed ponds (Table 4) can also be explained by a mallard's aerial selection process based on the peripheral tillage treatment. Ponds not tilled peripherally were used the most, followed by conservation tilled ponds, and lastly by plowed ponds. This lower use of tilled ponds is likely a result of tillage decreasing food availability. Plowing decreases the abundance of viable cropland weed (or moist-soil) seeds (Froud-Williams et al. 1983). Discing corn fields reduces total corn abundance by 79% and plowing reduces abundance even more (Baldassarre et al. 1983). While discing reduced corn abundance (Baldassarre et al. 1983), it increased availability by reducing litter and shattering ears into smaller pieces, causing disced fields to be heavily used by mallards (Baldassarre and Bolen 1984). While this might be an advantage to upland feeding waterfowl, it would have less advantage to mallards feeding in flooded sheetwater habitats. Mallards were also found to use cultivated and plowed fields most during snowstorms because such areas had reduced snow accumulation (Jorde 1981). This would be less important during the spring migration.

Disturbance factors were found to influence mallard use the least of the variables measured. Mallard use of ponds was not affected by farmsteads, but a positive relationship existed between distance of the pond from the nearest road and mallard use. This was not a strong relationship, and mallards often were observed using habitats adjacent to heavily travelled roads. These birds seemed to adjust to nearby traffic flow, but were disturbed by slow-moving (e.g., tractors) or stopped vehicles, and people outside of their vehicle. The relationship between use and distance from the road may also be partly attributable to increasing pond size with increasing distance from the road.

A mallard's selection of sheetwater habitats during spring migration undoubtedly involves a combination of the variables measured during this study. In addition, factors not measured, such as pesticide and fertilizer use, crop diseases, harvesting equipment, previous cropping history, weather, micro-climate, and flock size must influence mallard habitat selection. Another unknown factor in the habitat selection process was the role that tradition played. Tradition can significantly influence year-to-year use of habitats (Hochbaum 1955, Bellrose and Crompton 1970). Many additional factors need to be considered before all of the variability in mallard habitat use can be determined, but a significant amount of the variation can be explained by the four variables of pond size, vegetation, tillage, and distance from the nearest road.

While this study concentrated on habitat use of sheetwater by mallards during the daylight hours, it is important to recognize that almost half of the bird's 24 hr day is spent in a different habitat. The shift to larger emergent wetlands during the night possibly could be related to the favorable micro-climatic conditions provided by such cover (Jorde et al. 1984), a change to alternative food resources, behaviors adopted during the fall hunting season (Bellrose 1944), or to unknown socio-behavioral requirements related to migration. Further, more intensive, work is needed to understand more fully the importance of these habitats to spring migratory mallards.

MANAGEMENT IMPLICATIONS

Sheetwater habitats were extensively used by mallards during the spring migration. Even though not all ponds were used by mallards, the total habitat provided by the abundant sheetwater was tremendous. Not all sheetwater ponds were used equally by mallards, managers need to provide larger (> 2 ha) sheetwater ponds or shallow impoundments vegetated in moist-soil plants or corn, not-fall tilled or at most conservation-tilled, and located distally from roads and other disturbances. Areas managed in such a way will provide security, contain nutritious and/or high energy moist-soil plant seeds, tubers, and corn that can be used to meet the nutrient and energetic demands of the spring migration (see Section I).

While mallards used certain sheetwater habitats during the daylight hours, they shifted habitat use to larger emergent wetlands during nighttime. Therefore, providing habitat diversity is as important for the management of spring migratory mallards as it is for breeding (Dwyer et al. 1979), and wintering (Heitmeyer and Vohs 1984) mallards. Both sheetwater and emergent wetland habitat should be provided for use by spring migratory mallards.

Sheetwater habitat did not appear to be in short-supply in 1983 or 1984, but both springs were characterized by above-normal precipitation. It has been suggested that precipitation on the wintering grounds affects mallard recruitment (Heitmeyer and Fredrickson 1981). Precipitation on the spring migratory grounds, especially when below normal, must also influence mallard recruitment. More alarming than the occasional drier spring season are the potential impacts of long-term habitat changes. Wet soils (including sheetwater) can be an impediment to spring farming operations. Many proposals to remedy this problem exist, including a proposal to upgrade the drainage of an additional 1.6 million acres in a 10 county region of central Iowa (Anonymous 1983a), significantly reducing the amount of sheetwater habitat available.

While management of wildlife areas for spring migratory mallards is possible and desirable, little direct management is possible on the vast majority of sheetwater habitat under private ownership. Drainage subsidies, tax breaks for drainage improvements, farm programs that encourage conversion of "marginal" lands to row crop production, and fall tillage all contribute toward a decline in the quality and quantity of sheetwater habitat. Only through legislative action, changes in agricultural policy, and/or innovative conservation easment and tax programs can a substantial acreage of sheetwater habitat be protected.

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GENERAL SUMMARY

Comparisons of body and lipid weights of spring migratory hen mallards with those on the wintering and breeding grounds show that mallards are gaining weight and acquiring or maintaining lipid reserves during spring. These gains are occurring late (April) in the migration.

I propose three primary reasons why hen mallards are acquiring lipid reserves during spring migration. The first would be to gain reserves at a migratory stopover to be used as an energy source during the next migratory flight. Next, it would be to the bird's advantage to accumulate a reserve of lipids to be used to meet existence energy requirements during periods of inclement weather and corresponding periods of food scarcity. A final advantage would be for the hen to acquire lipid reserves during migration and then expend these reserves in search of invertebrates used for the exogenous protein required to produce the first clutch.

Several factors allow the spring migration to be a time of positive energy balance for paired hen mallards. Being paired allows the hen greater feeding time, enabling many hens to become hyperphagic. In addition, continental mallard populations reach a seasonal low, decreasing competition for available food resources. Finally, the spring is a time of increasing precipitation and melting snow, creating an abundance of seasonally-flooded habitats.

This abundant sheetwater habitat is heavily used by migratory mallards during the spring. Several characteristics of these habitats influenced mallard use, with pond size being one of the most important. Mallards used larger ponds (> 2 ha) more than smaller ponds. Large ponds potentially provide greater security and more feeding sites than smaller ponds. Mallard use also was influenced by tillage and vegetation type. Migratory mallards used moist-soil and corn ponds more than emergent wetlands or soybean ponds, and they used untilled ponds more than conservation-tilled or plowed ponds. The pond types used provide an abundance of highly nutritious and energy-rich moist-soil plant seeds and tubers, and corn. Mallards also used ponds located further from roads, decreasing the amount of human disturbance.

While this study concentrated on habitat use of sheetwater by mallards during daylight, it is important to recognize that the birds shifted use to larger emergent wetlands during the nighttime. A variety of activities occurred on these habitats but time did not allow intensive study. Further work is needed to determine the importance of these habitats to spring migratory mallards.

It is important to provide a diversity of habitats for mallards during spring migration. Both sheetwater ponds and emergent wetlands were used during a 24-hr period. In the long term, failure to meet the habitat and subsequent energetic needs of spring migratory mallards could lead to increased mortality and decreased recruitment. It is especially critical to insure that the remaining sheetwater and emergent wetland habitats be protected from further losses.

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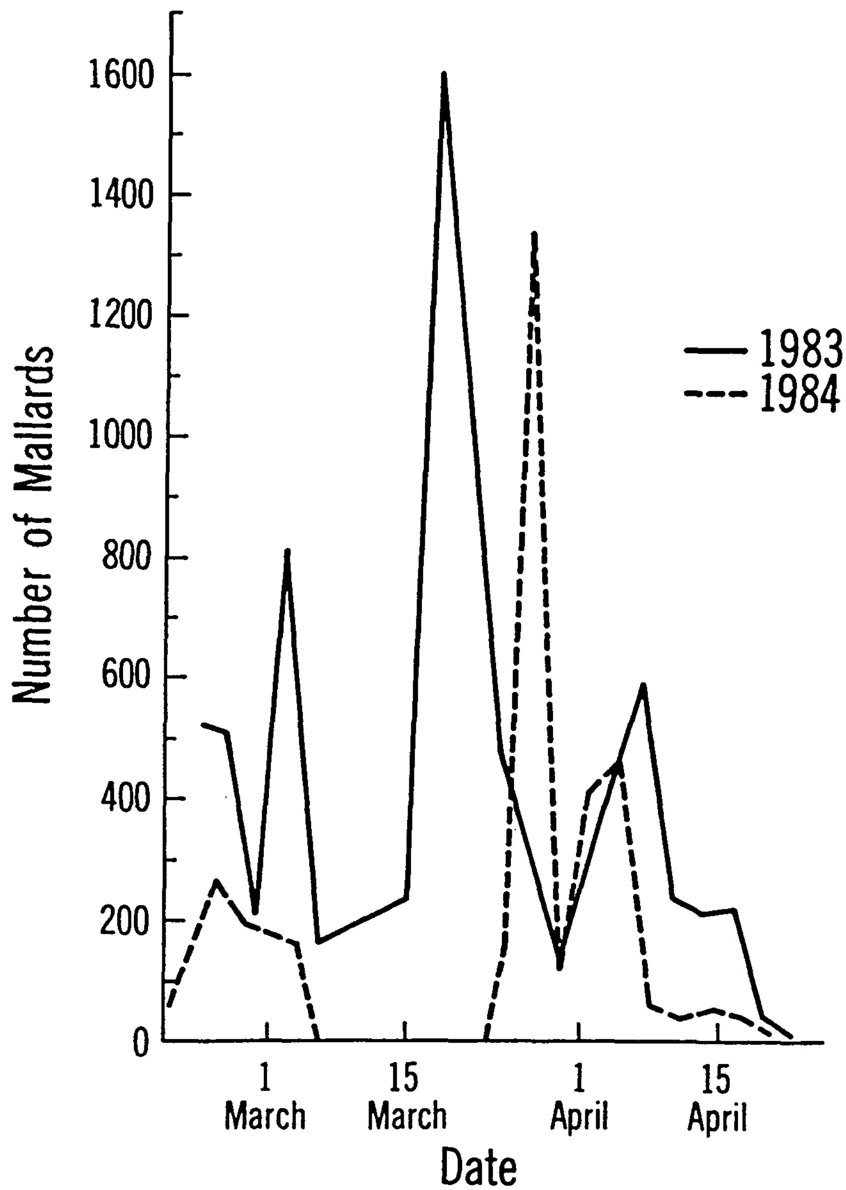
APPENDIX A

Graph showing the relationship between the number of mallards and date for 1983 and 1984. Mallard numbers were obtained from the roadside survey.



APPENDIX B

Summary of esophageal contents removed from 24 paired hen mallards collected during the spring migrations of 1983 and 1984. All birds were observed feeding for a minimum of 10-minutes.

Item	Aggregate % Dry Weight	Frequency of Occurrence
Corn (*Zea mays*)	17.3	21
Moist-soil plant seeds		
Wild millet (*Echinochloa* sp.)	4.9	63
Spike rush (*Eleocharis* sp.)	1.6	33
Rice cutgrass (*Leersia* sp.)	36.2	83
Smartweed (*Polygonum* sp.)	6.6	25
Foxtail (*Setaria* sp.)	3.3	21
Misc. seeds	3.0	67
TOTAL moist-soil plant seeds	55.6	96
Nutgrass tubers (*Cyperus* sp.)	17.5	38
Vegetative shoots	6.6	46
Misc. plant matter	0.8	29
TOTAL PLANT MATTER	97.8	100
TOTAL INVERTEBRATE MATTER	2.2	42

APPENDIX C

Summary of time activity budgets of paired hen mallards observed during the springs of 1983 and 1984. Based on 127 15-minute focal animal observations.

Activity	% Time Spent in activity
Feeding	40
Sleeping	27
Comfort movements	16
Loafing	8
Swimming	7
Alert	1
Courtship	1
Agonistic behavior	<1
Copulation	<1

APPENDIX D

Map of Story County, Iowa. Shading indicates roads that were travelled during roadside survey route in 1983 and 1984.